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FINAL TECHNICAL REPORT

STUDIES IN MUSCLE TRAINING (NEUROMUSCULAR MECHANISMS)

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CONTRACT Nonr-2944(00)

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The studies performed under this contract were concerned with indirect learning and its mechanisms. The first was designed to determine whether systematic training of the progressive resistance type administered to one muscle group of the wrist joint has a measurable influence on the functional capacity of the related agonist-antagonist pairs of the exercised limb and the contralateral extremity; the second described the overt behavioral responses as revealed photographically; the third explored the role of proprioceptive inputs aroused by different positions of the radioulnar joint on the involuntary patterning associated with exercise of the wrist.

Four series of experiments were performed over a period of three years. All observations were made on normal adult volunteers, the majority of whom were women. The subjects were intelligent, cooperative, highly motivated, and above average in neuromuscular skill. All exercise was performed on wrist ergographs constructed originally under ONR contract and made available through equipment loan contract Nonr-2944(00).

The initial and final functional capacity of wrist flexors or extensors was measured by administration of a standardized procedure consisting of successive bouts of 25 repetitive maximal contractions. The resistance was increased until the limits of strength and endurance were reached. Every subject was encouraged to make an all-out effort. The per diem work assignment of the training program consisted of 10 successive bouts of 25 repetitive contractions. Single or biplane serial photographs were taken, using 35-mm cameras equipped with motors and magazines capable of holding 50 feet of film. Flood lights were

synchronized with the camera shutters and triggered by a modified Samenco interval timer. A Valoy II enlarger and Kriser printer were used to bring the film image to appropriate size for analysis of changes in the posturing of the body as a whole or the relative alignment of primarily involved parts. Action potentials were picked up from motor points of the arm and shoulder girdle musculature by 8-mm bipolar disc surface electrodes and recorded on an 8-channel inkwriting Gilson electromyograph. Thus, three criteria of functional performance evolved simultaneously in many experiments, ergographic, photographic, and electromyographic.

The experimental subjects numbered 65. These yielded 815 ergographic observations. In 159 of these electromyograms were recorded simultaneously from 8 different muscles. More than 16,000 photographs were available for pattern analysis. The results may be summarized as follows:

1. Observation alone has a measurable influence on performance.
2. Practice limited to the flexors or extensors of the preferred side affects the performance of the agonist-antagonist complex of both sides.
3. The most conspicuous change in functional capacity is demonstrated by the muscle group subjected to direct practice.
4. Progressively increasing exercise stress evokes an orderly expansion of the motor response.
5. The way in which the willed aspect of the movement prescribed is ordered shows great intraindividual constancy but varies strikingly from subject to subject.

6. Young adults capable of pushing volitional performance to all-out effort exhibit relative functional decortication; responsiveness to extrinsic influences diminishes and behavior becomes increasingly stereotyped and automatic.

7. The adjustments which dominate such all-out effort appear to be subcortically controlled responses in which the tonic neck reflexes play a prepotent role.

8. The proprioceptive feedback from the radioulnar joint also has a profound effect on the patterning evoked by purposive movement of the wrist. The wrist joint agonist evokes associated activity in the biceps or triceps brachii and the linkage is fixed invariably by the positioning of the forearm during the performance.

9. Ability to isolate the action of the prime mover promotes the development of the purest associated motor figures. Pattern configurations are distinct when the associated complex evoked by the radioulnar joint has the same total limb function as the agonist.

10. The overt and covert patterning of the contralateral limb in unimanual exercise is reciprocal. Bilateral wrist exercise augments the sagittal plane component of the overt pattern.

11. Sensory input from the agonist is the primary determinant of the rotary head and shoulder component of the pattern; that from the radioulnar joint determines frontal and sagittal plane movements.

12. Wrist flexion from a position of supination is associated with protraction and depression of the shoulder girdle, ventroflexion of the vertebral column and the head, and contralateral rotation if the act is performed unimanually. Wrist extension from a position of

supination is associated with retraction and elevation of the shoulder girdle, extension of the vertebral column, dorsiflexion of the head, and ipsilateral rotation. The primary configuration of the motor response evoked by maximal effort against heavy resistance in standardized positions has a high degree of specificity. Thus, involuntary stress patterns appear to be common to all subjects. They are exaggerated by training but their basic organization is immune to remodeling.

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PUBLICATIONS:

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